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IMPROVED BLU-63.(U)
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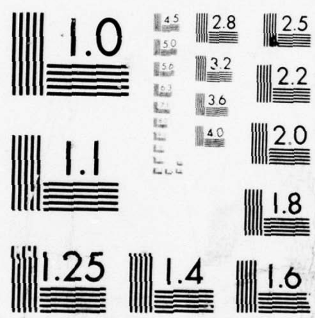

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IMPROVED BLU-63.

FINAL TECHNICAL REPORT,

CONTRACT NO. DAAK10-77-C-0021

PREPARED FOR:

U.S. ARMY ARMAMENT R&D COMMAND

DOVER, NEW JERSEY 07801

1978 54p.

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SUMMARY

This report describes the research and development of a molded plastic overlay shell for the XM74 Grenade (Improved BLU-63 Munition) to provide fins of a very sharp definition, required toughness, and improved aerodynamic characteristics for the ARRADCOM version of the grenade with a pre-engraved sintered tungsten shell for increased terminal effects. Aerodynamic analysis of the grenade with the BLU-26 fins confirmed the improved aerodynamic flight characteristics, and laboratory tests proved the required toughness of the molded plastic overlay. Tests conducted included pull apart at room and high temperature, simulated launch load at high and low temperature, impact at three temperatures, simulated storage, impact and pull apart after simulated storage, and burial tests. The design of the plastic overlay and crimp strap for tested grenades was documented, and the manufacturing process was defined. Burial tests were run on BLU-63 and Improved BLU-63 with standard and modified M219A1 fuzes. No significant difference in burial depth at time of function was noted.

INTRODUCTION

This report was prepared in response to DD Form 1423 Data Item 003, Final Technical Report, of Contract DAAK10-77-C-0021 as modified by Addendas 1, 2 and 3.

The accomplishments described are arranged and identified in accordance with the task descriptions as defined in the Scope of Work, Section F.1 of the contract with the exception of tasks which are administrative in nature or are included in the submittal of data items per DD Form 1423.

SECTION I

AERODYNAMIC DESIGN ANALYSIS

The BLU-26/B flute configuration aerodynamic data and the Improved BLU-63 mass properties data were used as inputs to the computerized trajectory analysis. The estimated Improved BLU-63 mass properties based upon measured and calculated information were utilized in this computer analysis. The results listed in Table 1 are based upon a grenade weight of 1.22 lb. (553 gm) and a polar moment of inertia of 0.929 lb-in^2 (2.72 kg-cm^2). Initial conditions assumed a 2,500 ft. (762 m) A.S.L. height of burst at a nominal -50 $\pm$ 5° downleg flight path angle and event velocities varying from 1,500 to 2,200 ft. per sec. (457.2 60 670.6 m per sec.). The maximum expected impact velocities under these conditions is nominally 275 ft. per sec. (83.8 m per sec.) and an estimated spin rate of 6,780 rpm at standard atmospheric conditions.

Table 2 shows results for the BLU-26/B for the same initial event conditions. Most notable result is that the Improved BLU-63 is expected to generate about a 200 foot smaller pattern as compared with the BLU-26 for the same event conditions.

TABLE 1

IMPROVED BLU-63

3 DIMENSIONAL TRAJECTORY

V_o (Ft/Sec)*	o (Deg)	$V_{I\ max}$ (Ft/Sec)*	P_d (Ft)**	R_I (Ft)**	$T_{I\ max}$ (Sec)	$T_{I\ min}$ (Sec)	Ω min (Rev/Sec)
1500	45	263.4	748.4	1974.4	8.9	7.0	114.6
1600	45	264.8	745.9	1991.8	8.8	6.8	114.6
1700	45	266.2	742.9	2007.8	8.7	6.7	114.6
1800	45	267.5	739.9	2022.7	8.6	6.6	114.6
1900	45	268.8	737.1	2036.7	8.5	6.5	114.6
2000	45	270.1	734.4	2049.9	8.4	6.5	114.6
2100	45	271.4	731.9	2062.2	8.3	6.4	114.6
2200	45	272.7	729.4	2073.9	8.2	6.3	114.6
1500	50	270.2	678.7	1725.1	8.0	6.5	113.2
1600	50	272.0	674.8	1739.1	7.9	6.4	113.2
1700	50	273.7	670.6	1751.9	7.8	6.3	113.1
1800	50	275.5	666.5	1763.8	7.7	6.2	113.0
1900	50	277.0	662.6	1775.0	7.6	6.1	113.0
2000	50	278.6	659.0	1785.4	7.5	6.0	112.9
2100	50	280.2	655.5	1795.2	7.4	5.9	112.8
2200	50	281.8	652.1	1804.4	7.3	5.8	112.8
1600	55	278.9	612.3	1494.6	7.2	6.0	111.7
1700	55	281.0	607.2	1504.7	7.0	5.9	111.6
1800	55	283.0	602.3	1514.1	6.9	5.7	111.5
1900	55	284.9	597.7	1522.8	6.8	5.7	111.4
2000	55	286.9	593.3	1531.0	6.7	5.6	111.3
2100	55	288.8	589.2	1538.6	6.6	5.5	111.1

V_o - Initial velocity at 2500 ft (762m)

o - Flight path angle

$V_{I\ max}$ - Maximum impact velocity

P_d - Pattern diameter

R_I - Range to impact

$T_{I\ max}$ - Max time to impact

T_I - Min time to impact

Ω min - Min spin rate at impact

* 1 Ft. per sec. = 0.3048 m/s

**1 Ft. = 0.3048m

TABLE 2

STANDARD BLU-26

3 DIMENSIONAL TRAJECTORY

V_o (Ft/Sec)*	o (Deg)	$V_{I\ max}$ (Ft/Sec)*	P_d (Ft)**	R_I (Ft)**	$T_{I\ max}$ (Sec)	$T_{I\ min}$ (Sec)	Ω min (Rev/Sec)
1500	45	221.3	956.8	1826.6	10.9	8.1	116.8
1600	45	222.0	453.8	1843.4	10.8	8.0	117.0
1700	45	222.6	950.2	1859.0	10.7	7.9	117.3
1800	45	223.1	946.7	1873.6	10.6	7.8	117.5
1900	45	223.7	943.7	1887.3	10.6	7.8	117.8
2000	45	224.3	940.3	1900.3	10.5	7.7	118.0
2100	45	224.8	937.3	1912.6	10.4	7.6	118.2
2200	45	225.4	934.4	1924.2	10.3	7.5	118.4
1500	50	224.8	886.3	1611.9	10.0	7.7	118.4
1600	50	225.6	881.8	1625.9	9.9	7.5	118.7
1700	50	226.3	876.9	1638.8	9.8	7.4	119.0
1800	50	227.1	872.1	1650.9	9.7	7.3	119.3
1900	50	227.9	867.5	1662.3	9.6	7.3	119.5
2000	50	228.6	863.2	1673.0	9.5	7.2	119.8
2100	50	229.3	859.1	1683.1	9.4	7.1	120.0
2200	50	230.0	855.1	1692.6	9.3	7.0	120.3
1500	55	228.2	820.5	1398.0	9.1	7.2	119.7
1600	55	229.2	814.7	1409.4	9.0	7.1	120.0
1700	55	230.1	808.5	1419.9	8.9	7.0	120.3
1800	55	231.1	802.6	1429.7	8.8	6.9	120.6
1900	55	232.0	797.0	1438.9	8.7	6.8	120.8
2000	55	232.9	791.7	1447.5	8.6	6.8	121.1
2100	55	233.8	786.6	1455.6	8.5	6.7	121.3
2200	55	234.7	781.7	1463.3	8.4	6.6	121.5

* 1 Ft. per Sec. = 0.3048 m/s

**1 Ft. = 0.3048m

SECTION II

MOLDED OVERLAY DESIGN

Vibrathane B665/3095 (urethane) was selected for the molded overlay due to the materials physical properties, bond strength, and adaptability to high volume production. Previous work on plastic overlay for BLU-71 submunition had demonstrated the capability to properly mold and compatibility with Cyclotol 70/30. Cyclotol 70/30 is a composition of RDX/TNT of 70 and 30% respectively while composition B is a 60/40 mix of the same constituents.

The bond strength of Vibrathane B665/3095 was tested on both steel and sintered tungsten blanks with the results shown in Table 3. Test report is included in Appendix B.

All measured physical properties met or exceeded supplier published data. The current practice is to mechanical tumble the hemispheres which provide a surface similar to the sand blasted surface. The sand blasted tungsten provides adequate adhesion, therefore, solvent washing or chemical etch will not be required.

Three configurations of the molded flange and crimp strap were fabricated and tested to determine the proper configuration to meet the requirement of 675 lb. (3003 N) minimum pull force and provide acceptable mass properties for proper function of the submunition. The three configurations were:

TABLE 3

VIBRATHANE BOND STRENGTHS

Material	Bond Strength
Unprimed Steel	5,000 PSI (34.47 Mpa)
DK-8 Epoxy Primed Steel	5,500 PSI (37.92 Mpa)
Sintered Tungsten Sabot Washed Surface	4,686 PSI (32.31 Mpa)
Sintered Tungsten, Band Blasted Surface	5,033 PSI (34.70 Mpa)

(1) original BLU-26 flange dimensions and steel band, (2) increased flange diameter and flange thickness with a wider steel crimp band but keeping the 0.020 inch (0.51 mm) thickness, and (3) the same flange and steel crimp band as in (2) but increasing the crimp band thickness to 0.031 inch (0.79 mm). The third configuration with the modified flange and wider and thicker crimp band was the only configuration that met the 675 lb. (3003 N) pull strength. This configuration was used in all subsequent fabrication and tests.

The first configuration tested consisted of the molded urethane with the original BLU-26 flange dimensions, and the original steel band.

The second configuration was made with the flange diameter increased from 2.483 - .011 inch (63.07 - 0.28 mm) to 2.503 inch (63.58 mm) and the flange thickness was increased from 0.071 - 0.13 inch (1.80 - 0.33 mm) to 0.102 inch (2.59 mm) with a 12° taper and an approximately 0.010 inch (0.25 mm) radius between the flange and spherical outside diameter. The crimped steel band was made of annealed, 0.020 inch (0.51 mm) thick, 302/304 stainless sheet to keep the moment-of-inertia and weight at a minimum. The band was made approximately 0.060 inch (1.52 mm) wider than the original band to fit the larger flange, and was butt welded using a carbon dioxide laser.

The third configuration was made with the same size flange as the second trial, but the band thickness was increased to 0.031 inch (0.79 mm) and was butt welded by hand using the tungsten inert gas method. Three units were tested and reached 1,000 lb. (4448 N) without separation, see Table 4.

TABLE 4

PULL FORCE TEST

UNIT NUMBER	TEMP.	PEAK PULL FORCE	REMARKS
Configuration (1) Original BLU-26			
No. 1	Amb.	586 lb (2607 N)	
Configuration (2)			
No. 1	Amb.	525 lb. (2335 N)	
No. 2	Amb.	500 lb. (2224 N)	
Configuration (3)			
No. 1	Amb.	1000 lb. (4448 N)	No failure.
No. 2	Amb.	1000 lb. (4448 N)	No failure.
No. 3	Amb.	1255 lb. (5583 N)	
No. 1	+160°F	640 lb. (2847 N)	Previously tested to 1000 lb. at ambient.
No. 2	+160°F	440 lb. (1957 N)	Previously tested to 1000 lb. at ambient
No. 4	+140°F	773 lb.	
No. 5	+140°F	784 lb.	
No. 6	+140°F	566 lb.	Flange sheared off.
No. 7	+140°F		From storage test.
No. 8	+140°F		From storage test.
No. 9	- 25°F		From storage test.
No. 10	- 25°F		From storage test.

One of the units was then pulled to failure at 1,255 lb. (5583 N). Complete pull test results are shown in Table 4. Assembly is shown in Figure 9.

Observation of the breakaway moment shows that the molded urethane (slightly more flexible at elevated temperature) crawls out from the crimp band on the same side, i.e., that which faced upward in the crimp tool. This side is not quite closed due to use of an existing BLU-26 crimp tool which does not exactly fit the redesigned band. A change in this tool should provide higher test results.

Unit #6 failed in urethane shear. The usual mode is for the urethane to pull out from under the crimp. This type of failure (urethane shear) has not been seen in any other load tests, even in the unit that failed at 1,255 lb. (5583 N). It is felt that this unit was not representative due to molding anomalies or excessive crimp causing a notch in the overlay.

The mass properties (moment of inertia and weight) of the selected configuration were obtained and utilized in the aerodynamic computation of trajectories. Table 5 shows the moments of inertia and Table 6 the weight.

One inert unit with simulated live weight was measured to determine the moments-of-inertia. Results are as follows:

Weight	1.207 lb (547.5 gm) (-1.24%)
Polar Axis	0.9068 lb-in^2 (2.65 kg-cm^2) (-2.37%)
Transverse	0.8689 lb-in^2 (2.54 kg-cm^2) (-1.26%)
Ratio of Polar to Transverse	1.04 (-1.12%)

Table 5

Moments-of-Inertia

	Moment-of-Inertia				
	Polar		Transverse		
	lb.-in^2	kg-cm^2	lb-in^2	kg-cm^2	Ratio
1. XM74 Steel Shell over Tungsten (measured)	0.967	2.83	0.928	2.72	1.042
2. Steel Shell (measured)	-0.1239 0.98431	-0.36 2.47	-0.1084 0.8196	-0.32 2.39	
3. New Plastic Shell (measured)	+0.0495 0.8926	+0.14 2.61	+0.0421 0.8617	+0.12 2.52	
4. .030 in. Steel Band (Calc)	+.0361 0.9287	+0.11 2.72	+0.0183 0.8800	+0.05 2.58	1.0553

Table 6

Weights of Parts

			lb.	g
1.*	Tungsten	Female	0.403	182.8
		Male	0.423	191.9
2.*	Explosive	Female	0.136	61.7
		Male	0.142	64.4
3.*	Fuze 219E1		0.050	22.7
4.	Plastic Shell (Measured)	Female	0.022	9.9
		Male	0.024	10.9
5.	Metal Band (.030) (Calc.)		0.022	9.9
			1.222	554.3

*From Olin Frazer for the PA version of the BLU-63.

The percentages show deviation from estimated values reported in Table 1.

The baseline design was documented on the following drawings.

Drawing Number	Title
28115052	Grenade, Improved BLU-63, Inert Loaded
28115051	Top Loading Assembly, Inert
28115050	Base Loading Assembly, Inert
28114861	Strap
28114926	Hemisphere Assembly, Top
28114925	Hemisphere Assembly, Base

The Improved BLU-63 Grenade is an XM74 Grenade with a molded plastic overlay shell with fins conforming to the BLU-26 configuration.

SECTION III

HARDWARE FABRICATION

The processes, tools and equipment used to manufacture the Improved BLU-63 munition are delineated in this section. The procedures developed are based upon the processes previously used for the BLU-61, and are, therefore, adaptable to that program's automated assembly line. Approximately 110 sets of parts were molded and assembled in the laboratory for tests. Test results and detail process are included in Appendix B.

The process is described as follows:

A. Materials and Tools for Molding

Materials Required:

1. Vibrathane B665, manufactured by Uniroyal, Inc.
2. Vibracure 3095, manufactured by Uniroyal, Inc.
3. Urethane Red Past #BH, manufactured by Verona Diestuffs, Inc.
4. Hysol 4368 Silicone Mold Release, manufactured by Hysol Inc.

Tooling and Equipment Requirements:

1. Modified BLU-27 diecast die DPPM65D12099-T2
2. One small arbor press
3. One microwave oven for preheating raw materials
4. One hot air convection laboratory oven for curing product and preheating mold.

B. Metal Shell Preparation

1. Sandblast part number 9298784 and part number 9298785, ARRADCOM drawings on the external surfaces to provide a uniform matt finish. Use grit of 80 to 120 mesh.
2. Just prior to molding, wash each shell by immersion in a clean bath of acetone.

C. Mold Preparation

1. Coat molds with Hysol 4368 silicone mold release. See Figure 1.
2. Preheat molds to 250^{O}F until dry.
3. Attach the tungsten metal shell to mold force. See Figure 2.

D. Molding Procedure

1. Preheat Vibrathen B665 to 190^{O}F in a closed container.
2. Preheat Vibracure 3095 to 250^{O}F in a closed container.
3. Weigh 100 parts of B665 into a container. Add 1 part Verona Red Paste No. BH. Then add 21.7 parts of 3095.
4. Mix parts A, B, and Die together thoroughly and rapidly using a power rotary shear mixer.
5. Place the mixture in a vacuum chamber and evacuate at between 2 and 4 torr vacuum for a cycle time of 1 minute and 15 seconds.
6. Pour this mixture into the 250^{O} preheated mold and close mold using an arbor press in approximately 30 seconds.
7. Return molds to oven and cure for 1 hour at 250^{O}F.

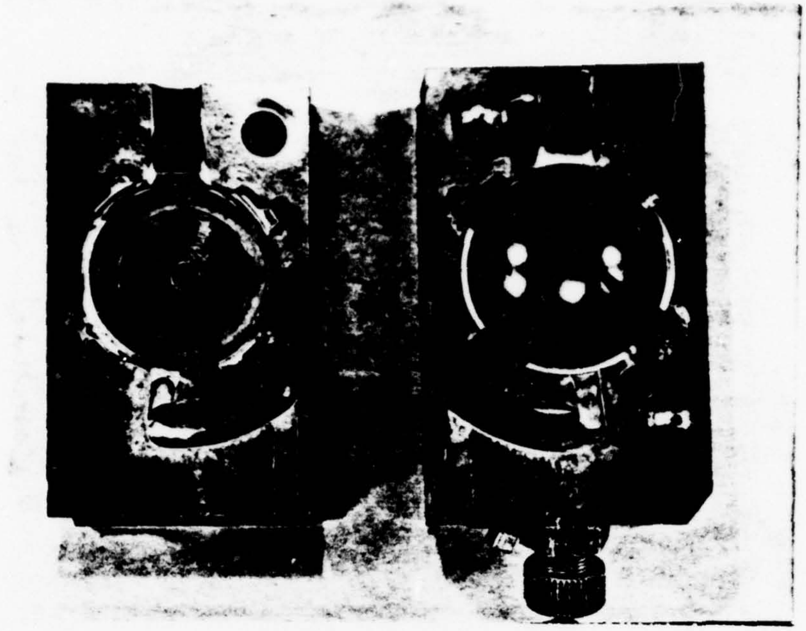


FIGURE 1 - PREPARED MOLDS

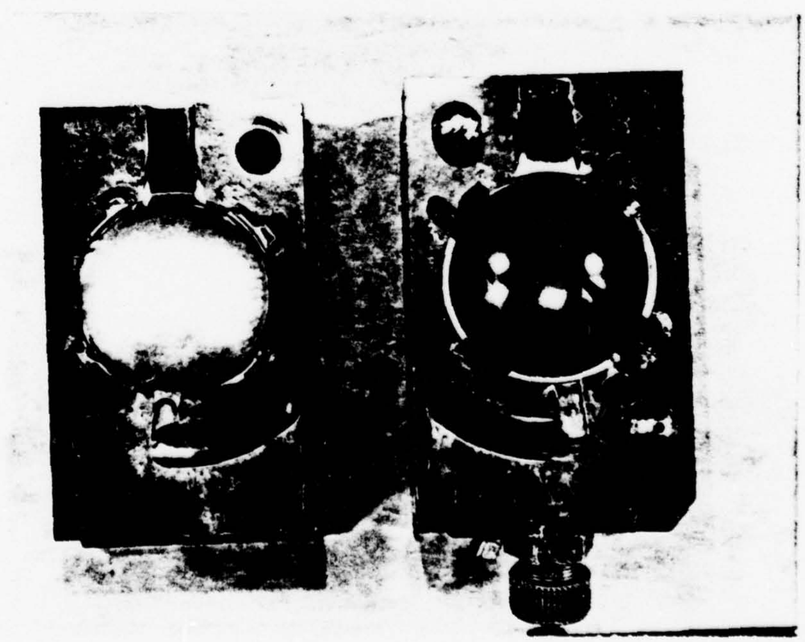


FIGURE 2 - READY FOR MOLDING

8. Remove molds from oven and demold while hot. See Figure 3.

9. Postcure each part 40 hours at 250°F.

10. Remove parts from oven and remove flash and excess material by hand trimming using scalpel and scissors.

E. Materials and Equipment for Casting Inert Fill

Materials Required:

1. Epon 815 resin manufactured by Shell Chemical Corporation.
2. Curing Agent U manufactured by Shell Chemical Corporation.
3. Aluminum 101 manufactured by Alcoa Corporation.

Equipment Required:

1. One each upper and lower casting fixtures. See Figure 4.

F. Process for Casting Inert Fill

1. Weigh 4 parts of Epon 815 into a container.
2. Weigh 1 part of Curing Agent U into the same container.
3. Weigh 5 parts of Aluminum 101 into the same container.
4. Mix material thoroughly using a rotary power shear mixer.
5. Evacuate the entrapped air from the material for 4 minutes maximum at 2-4 torr vacuum.
6. Cast this material through fill holes of fixtures into the BLU-63 cavities at room temperature.
7. Cure this mixture for 4 hours at room temperature.
8. Demold.

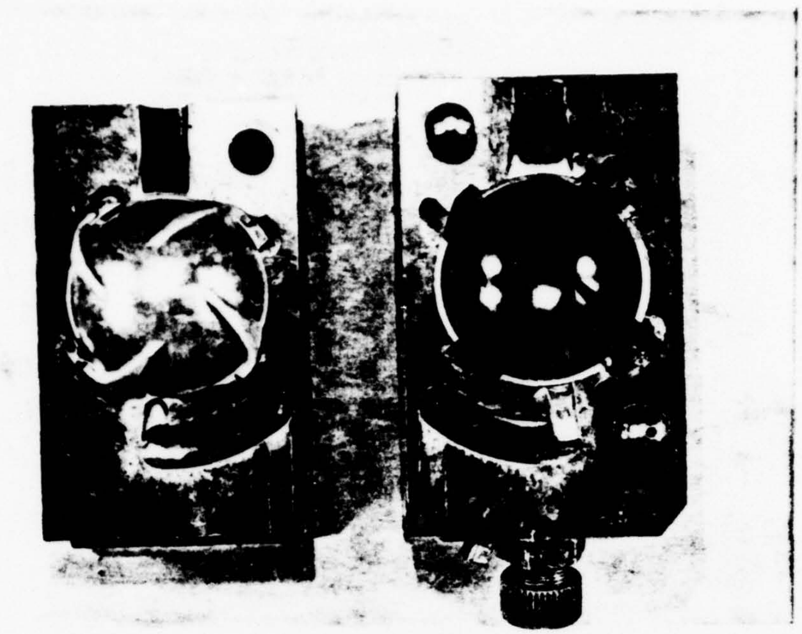


FIGURE 3 - AFTER MOLDING OVERLAY

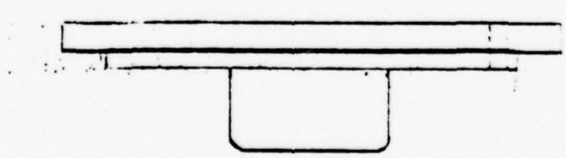


FIGURE 4 - CASTING FIXTURE

9. Clean up flash by hand trimming.

10. Machine any excess length of sprue which is left over from the filling operation. See Figure 5.

G. Final Assembly

1. Insert one 219E1 fuze spring into top loading assembly No. 28115051-101.

2. Insert one 219E1 fuze into the same side of the assembly with output side of fuze facing upward and away from the assembly. See Figure 6.

3. Apply Dow Corning silastic sealant bead so as to create an X across the cavity and onto the equator surface of the part. The bead should be approximately 1/8" in diameter by 1-1/2" long in an X pattern. Immediately after this application apply the base loading assembly No. 28115050-101 in place while locating a stainless steel crimp band No. 28114861-101 between the two mating halves. See Figure 7. Place the unit in the BLU-26 crimp die (Honeywell Tool No. X69F4143-T1-1).

   Note: Die should be mounted in a hydraulic press. The press shall then be closed at 800 psi gauge pressure (approximately 22,620 lbs. of force applied to the die).

   Note: Four shims of .062 of an inch thickness shall be located at the closing faces of the crimp die to preclude total closure.

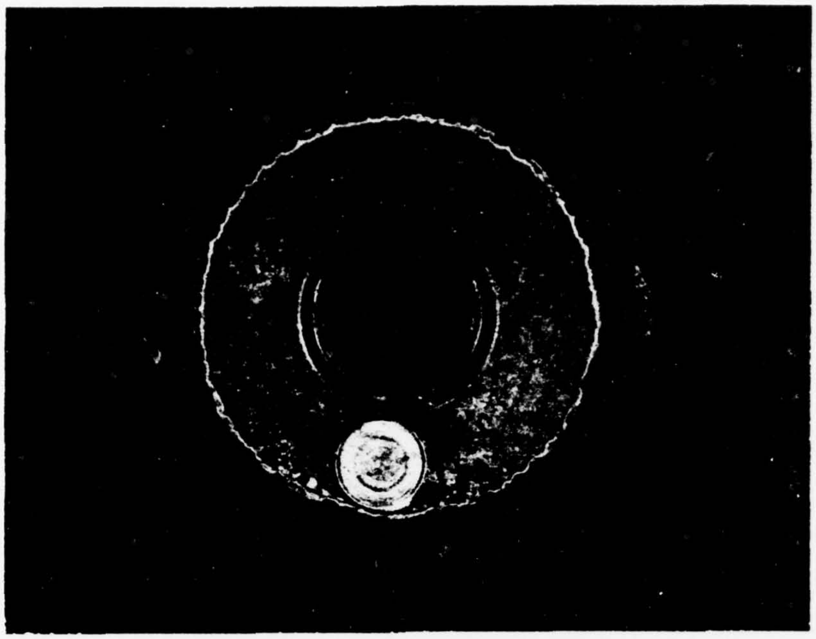


FIGURE 5 - MOLDED INERT FILLER

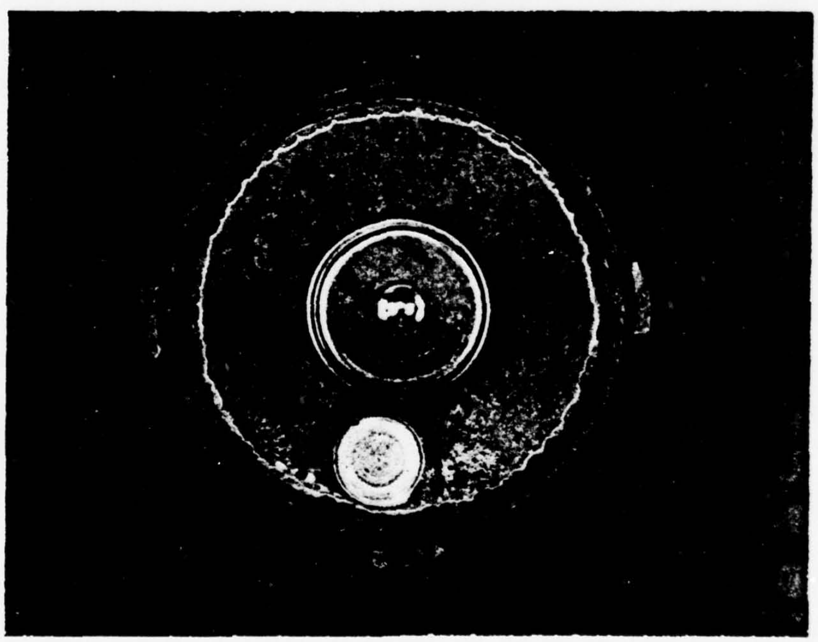


FIGURE 6 - FUZE INSERTED

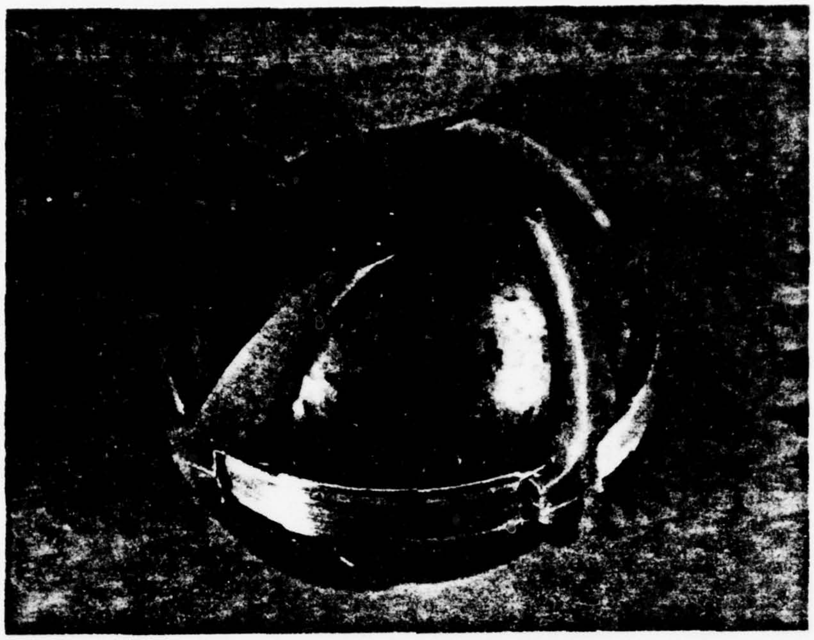


FIGURE 7 - ASSEMBLY READY FOR CRIMPING

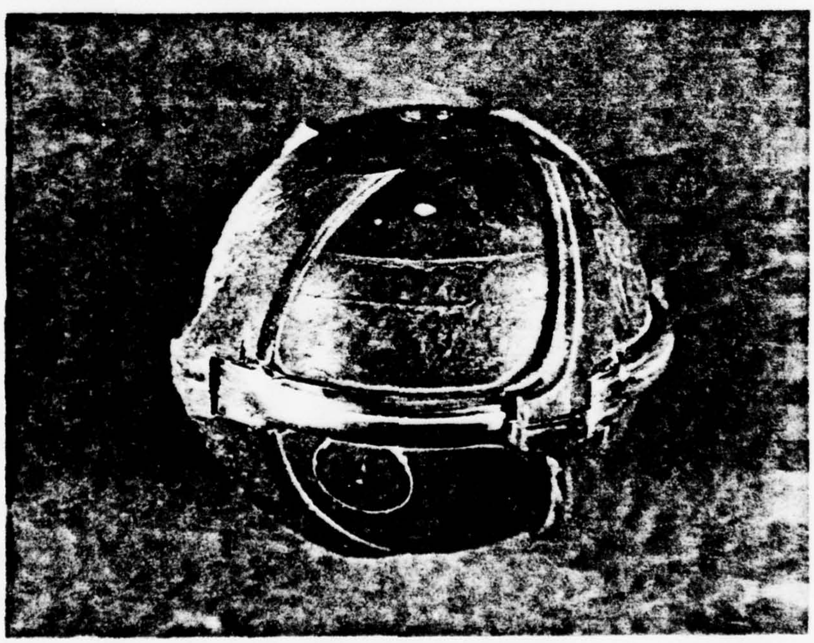
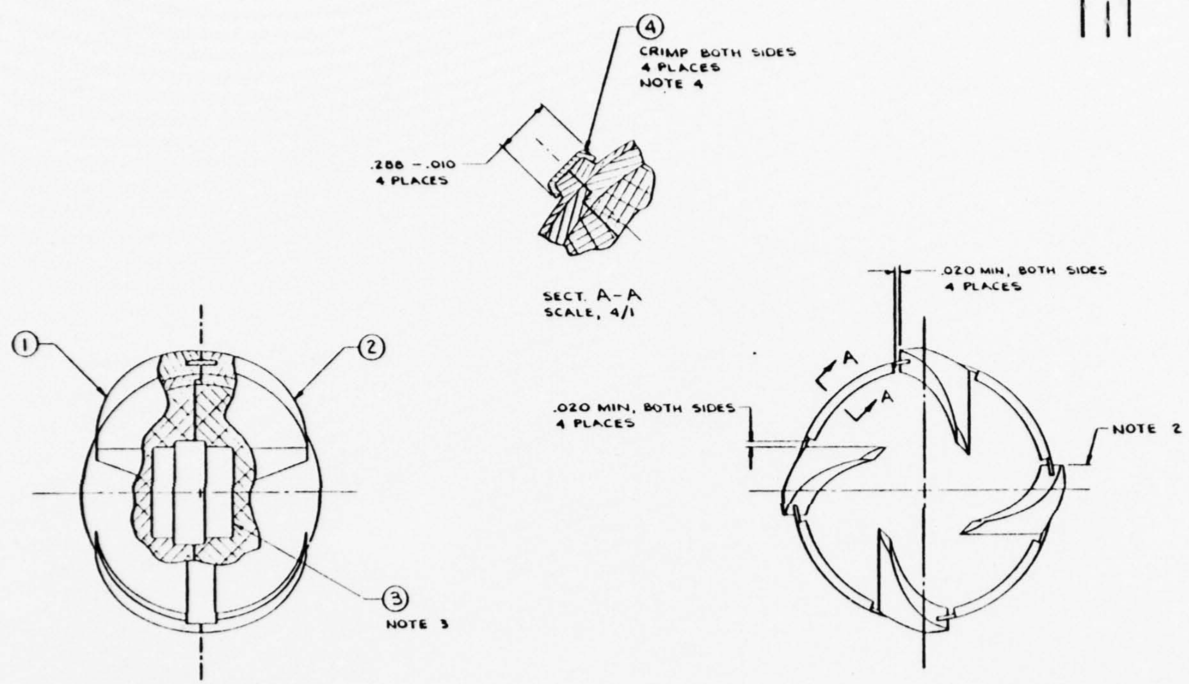


FIGURE 8 - COMPLETED IMPROVED BLU-63 MUNITION

Remove assembled inert grenade from crimp die and allow to cure for 24 hours at room temperature.

Figure 8 shows the completed munition and Figure 9 is the top assembly drawing.

PART NO. 28115052-101



NOTES:

1. SPEC MIL-A-2550 AND ANSI Y14.5-1973 APPLY.
2. FLUTES SHALL BE ALIGNED WITHIN .050 MAX.
3. APPLY 1.0 ± .5 CC OF SEALANT, SPEC MIL-S-48112.
4. CRIMP SHALL WITHSTAND A SEPARATION FORCE OF 675 LB. MIN.

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ITEM NO.
1	28114861-101	STRAP	4
1		FUZE, 219E1, INERT	3
1	28115051-101	TOP LOADING ASSEMBLY, INERT	2
1	28115050-101	BASE LOADING ASSEMBLY, INERT	1

IMPROVED BLU 63

CONTRACT NO. DAAK10-77-C-0021

Honeywell

DEFENSE SYSTEMS DIVISION
600 2ND STREET NE
HOPKINS MINNESOTA 55343

GRENADE, IMPROVED
BLU 63, INERT, LOADED

D | 08638 | 28115052

SCALE 2/1

CONTROL

FIGURE 9

SECTION IV

EMPIRICAL ANALYSIS

The objective of the empirical analysis was to conduct survival tests on the XM74 Grenade. Tests conducted included pull tests at room and high temperature, simulated launch load at high and low temperature, impact at three temperatures, simulated storage, and impact and pull apart after simulated storage.

The test plan for the empirical tests is shown in Attachment A.

Pull Tests

Pull tests were performed on units to determine pull forces required to separate the hemispheres. Results of these tests are reported in Section II. Molded Overlay Design.

Simulated Launch Loads

Four units were subjected to a simulated launch load.

The test plan for launch load was modified to use the Tinius-Olsen test machine to apply a controlled load. The launch load test was accomplished by using a Tinius-Olsen tensile test machine to apply the simulated launch load force onto a stack of four units. The units were stacked so that the force from one unit would be carried by the flutes of the other 3 units. Loads of 500 and 1,000 lb. (2224 and 4448 N) were applied for 2 min. with the units at the specified temperatures of $-25^{\circ}F$ and $+140^{\circ}F$. Deformations

of the flutes were very small (few thousandths of an inch) (less than 0.1 mm). Test report is included in Appendix B.

Impact Load Test

The impact load test per paragraph 3.3 of the Test Plan was completed. The velocity of each grenade was measured just before impact by means of an x-band radar. The mean velocity of the ten shots was 268.6 ft. per second (81.87 m/s) and the standard deviation of the lot was 3.04 fps (0.93 m/s). One shot at ambient temperature was at 262 fps (79.9 m/s) and one shot at 140°F (60°C) was at 264 fps (80.5 m/s) which are respectively 3 and 1 fps (0.9 and 0.3 m/s) below the minimum specified 265 fps (80.8 m/s). There was no separation of any of the hemispheres; all straps and flanges remained intact during and after impact.

Storage Load Test

The storage load test on 10 units was conducted per paragraph 3.4 of the test plan. The 28 day storage load test conducted at 160°F (71°C) showed no significant changes in shape of the flutes.

Three of the above units were impact tested at 275 ft/sec (83.8 m/s); one at room temp. and one at 140°F (60°C) with no detrimental effects. The one unit tested at -25°F (-32°C) experienced a cracking of the tungsten at the equator. The molded urethane and the crimp band held this unit together, effectively, to the extent that, had it been a live unit, full function would have occurred.

Four storage test units were pulled apart to determine crimp strength. Two at 140^{O}F (60^{O}C) had an average strength of 625 lbs. (2780 N), and two at -25^{O}F (-32^{O}C) had an average strength of 1,300 pounds (5787 N). Observation of the unit at separation at 140^{O}F (60^{O}C) shows that the molded urethane (slightly more flexible at elevated temperature) always crawls out from the crimp band on the same side, i.e., that which faced upward in the crimp tool. This side is not quite closed due to use of an existing BLU-26 crimp tool which does not exactly fit our BLU-63 redesigned band. A change in this tool would provide higher test results at elevated temperatures. Test report is included in Appendix B.

Burial Tests

Forty-five munition burial tests were conducted on the original BLU-63 and Improved BLU-63 munitions. Fuzes used in the test program were from the following lot numbers:

Standard M219A1 - Lot MHR 54-9

Modified M219A1 - Lot MHR 54-16

The tests were conducted to determine BLU-63 and munition burial distance at time of fuze function on three media. The media used were sand, compacted to 40 PSI (276 kPa), soil, compacted to 120 PSI (827 kPa), and 3-1/3 inch (88.9 mm) of chipboard with 1/2 inch (12.7 mm) of steel backing. This latter media simulates asphalt.

Test results show that munition burial depth at time of function:

- is not affected by the M-219 modified fuze,
- is not affected by the heavier, faster flying Improved BLU-63 munition,
- varies with impact velocity, and
- varies with media hardness.

Burial is defined as the distance from the top of the undisturbed surface of the media prior to munition entry, to the bottom of the munition as it came to rest.

BLU-63 munitions separated and did not bury, with the exception of one which buried in soil. This separation was believed to be caused by the crimp which was made by hand, since no tooling was available.

The procedure used to obtain the burial data is as follows.

An air gun with a rectangular cross section was used to launch the munition. The munition was placed into a sabot and a ribbon was wound around the outside to spin the sabot on launch. A 10 giga-hertz radar was used to determine munition velocity. A foil switch on the surface of the media was used to provide a signal that the munition was entering, and a light sensor was used to detect fuze function. A 1/4 inch (6.35 mm) diameter hole was drilled into the munition to provide a fuze function flash hole. The radar signal, the foil switch function and the light sensor signal were recorded on a storage oscilloscope. All data was obtained from the 3 signals retained on the scope.

Fastex camera shots were taken to measure the munition spin rate. The pictures also show that the BLU-63 does come apart. However, munition impact, fuze function and munition separation are on one frame of film. Results of the film analysis are shown in Table 9.

Harness of the media was obtained using a cone penetrometer. The cone has an area of 1/2 sq. in. (323 mm^2) and was pressed into the media a distance of 3 inches (76.2 mm).

A complete data summary is shown in Table 7 with all data in Table 8. Final munition burial data was not obtained in all tests because the spinning munition climbed out of the media.

TABLE 7

DATA SUMMARY FOR

MUNITION BURIAL TEST

Munition Type	Fuze Type	Impact Media	Average Velocity Ft/Sec (m/s)	Average Fuze Function Time Micro Second	Average Munition Burial at Time of Function Inch (mm)
Blu-63*	M219A1	Sand	226 (68.9)	343	0.93 (23.6)
		Soil	227 (69.2)	347	0.94 (23.9)
		Chipboard	227 (69.2)	310	0.84 (21.3)
XM74**	M219A1	Sand	270 (82.3)	281	0.91 (23.1)
		Soil	277 (84.4)	215	0.71 (18.0) (Four Data Points)
		Chipboard	272 (82.9)	244	0.80 (20.3)
XM74**	Modified† M219A1	Sand	274 (83.5)	265	0.82 (20.8)
		Soil	273 (83.2)	244	0.80 (20.3)
		Chipboard	274 (83.5)	243	0.80 (20.3)

*GFM supplied by ARRADCOM under separate contract.

**The munition actually tested was the Improved Blu-63 (28115052).

†GFM from separate Honeywell contract.

TABLE 8

TEST RESULTS OBTAINED FROM

MUNITION BURIAL TESTS

Munition	Fuze	Media	Velocity Ft/Sec (m/s)	Fuze Function Time Micro/Second	** Munition Burial Depth at Function Inch (mm)	Munition Final Burial Depth Inch (mm)
Blu-63	M219E1	Sand	224 (68.3)	295	0.79 (20.1)	
		(40 PSI)	226 (68.9)	355	0.96 (24.4)	
		(276 kPa)	227 (69.2)	400	1.09 (27.7)	
			224 (68.3)	315	0.85 (21.6)	
			228 (69.5)	350	0.96 (24.4)	
		Soil	230 (70.1)	245	0.67 (17.0)	
		(120 PSI)	223 (67.9)	425	1.14 (28.9)	3.75 (95.3)
		(827 kPa)	228 (69.5)	370	1.01 (25.6)	
			228 (69.5)	320	0.87 (22.1)	
			225 (68.6)	375	1.01 (25.6)	
		Chipboard	228 (68.6)	335	0.92 (23.4)	
			229 (69.8)	315	0.87 (22.1)	
			228 (68.6)	290	0.79 (20.1)	
			223 (67.9)	255	0.68 (17.3)	
			228 (68.6)	355	0.97 (24.6	

TABLE 8 (CONTINUED)

Munition	Fuze	Media	Velocity Ft/Sec (m/s)	Fuze Function Time Micro/Second	** Munition Burial Depth at Function Inch (mm)	Munition Final Burial Depth Inch (mm)
Improved Blu-63	M219A1	Sand	270 (82.3)	285	0.92 (23.4)	3.0 (96.2)
			270 (82.3)	265	0.86 (21.8)	
			271 (82.6)	315	1.02 (25.9)	3.4 (86.4)
			271 (82.6)	310	1.01 (25.6)	3.0 (76.2)
			269 (82.0)	230	0.74 (18.8)	4.0 (101.6)
		Soil	270 (82.3)	225	0.73 (18.5)	4.0 (101.6)
			279 (85.0)	215	0.72 (18.3)	3.75 (95.3)
			280 (85.3)	60*	0.20 (5.1)	3.75 (95.3)
			283 (86.3)	210	0.71 (18.0)	4.0 (101.6)
			276 (84.1)	210	0.69 (17.5)	3.25 (82.6)
		Chipboard	275 (83.8)	240	0.79 (20.1)	
			271 (92.6)	205	0.67 (17.0)	
			271 (82.6)	270	0.88 (22.4)	
			271 (82.6)	300	0.97 (24.6)	
			271 (82.6)	205	0.67 (17.0)	

Munition Weight as tested

Improved Blu-63 1.22 pounds (553 gm)

Blu-63 0.93 pounds (422 gm)

*May have hit a piece of rock in soil.

**Assumes no loss of velocity - this is the distance in inches between the top of the undisturbed media and the bottom of the munition.

TABLE 8 (CONTINUED)

Munition	Fuze	Media	Velocity Ft/Sec (m/s)	Fuze Function Time Micro/Second	** Munition Burial Depth at Function Inch (mm)	Munition Final Burial Depth Inch (mm)
Improved Blu-63	Modified M219A1	Sand	275 (83.8)	240	0.77 (19.6)	
			275 (83.8)	305	1.00 (25.4)	
			269 (82.0)	280	0.90 (22.9)	
			275 (83.8)	185	0.61 (15.5)	
			278 (84.7)	240	0.80 (20.3)	
		Soil	277 (84.4)	240	0.80 (20.3)	3.25 (82.6)
			271 (82.6)	245	0.80 (20.3)	3.50 (88.9)
			271 (82.6)	255	0.83 (21.1)	3.75 (95.3)
			275 (83.8)	230	0.76 (19.3)	3.75 (95.3)
			271 (82.6)	250	0.81 (20.6)	3.0 (76.2)
		Chipboard	273 (83.2)	225	0.74 (18.8)	
			272 (82.9)	230	0.75 (19.1)	
			275 (83.8)	250	0.83 (21.1)	
			275 (83.8)	265	0.87 (22.1)	
			275 (83.8)	245	0.81 (20.6)	

TABLE 9

MUNITION VELOCITY VS. SPIN RPM

Velocity Ft/Sec (m/s)	Spin RPM	Camera Film Frame Rate Frames/Second
244 (74.4)	5375	4300
234 (71.3)	5647	3200
237 (72.2)	5667	3400

APPENDIX A

IMPROVED BLU-63 TEST PLAN

APPENDIX A

IMPROVED BLU-63 TEST PLAN

1.0 SCOPE - This test plan defines the Improved BLU-63 configuration, and defines development tests.

2.0 CONFIGURATION - The following listed drawings define the configuration to be tested and shipped:

Drawing Number	
9298784	Hemisphere, Tungsten (Picatinny Arsenal)
9298785	Hemisphere, Tungsten (Picatinny Arsenal)
28114925	Hemisphere, Base Assembly
28114926	Hemisphere, Top Assembly
28114861	Strap
28115051	Top Loading Assembly INERT
28115050	Base Loading Assembly INERT
28115052	Grenade, Improved BLU-63, Inert, Loaded

3.0 DEVELOPMENT TESTS

3.1 Pull Apart (6 Units)

3.1.1 Room Temperature - Use a Tinius Olsen Machine to pull apart two hemispheres with the crimp band at the equator. The load at failure shall exceed 675 lb. Pull test 3 assemblies at a rate of 20 inches/minute.

3.1.2 High Temperature - Soak assembly at $140^{o}F \pm 5^{o}F$ for 1 hour min. and pull apart while at temperature. The load at failure shall exceed 675 lbs. Pull test 3 assemblies at a rate of 20 inches/minute.

3.2 Launch Load (10 Units)

Use a centrifuge to apply 50 g's for 2 minutes. Measure flutes before and immediately after application of the g load to determine flute deformation. After the launch load test, these units shall be available for any additional tests that may be required.

3.2.1 Low Temperature - Soak assemblies at least 1 hour in a chamber maintained at $-25 \pm 5^{o}F$ then apply g load while at temperature. Test 5 units.

3.2.2 High Temperature - Soak units for 1 hour minimum in a chamber maintained at $140 \pm 5^{o}F$ then apply g load while at temperature. Test 5 units.

3.3 Impact Load (10 Units)

Air gun launch assembly at $275 ^{+0}_{-10}$ ft. per second to impact at 90 ± 5 deg. against ASTM C33-74a Fine Aggregate packed to 40 psi. The assemblies shall be oriented to impact on the crimped strap.

Soak the number of units at each of the following three temperatures for at least 1 hour and air gun launch while units are at temperature:

1) -25 $\pm$ 5^{O}F (4 Units)
2) 70 $\pm$ 5^{O}F (3 Units)
3) 140 $\pm$ 5^{O}F (3 Units)

Examine and record damage.

3.4 Storage Load (10 Units)

3.4.1 Storage - Stack assemblies in confinement tube to simulate storage in the Lance Warhead configuration. Flutes shall be marked and oriented for worst case material creep. Place stacked assemblies and confinement tube in chamber maintained at 160 $\pm$ 5^{O}F for 30 days. Measure deformation of flutes at the end of 1 day, 3 days, 7 days and weekly thereafter, for a total of six measurements. Plot data to show deformation versus elapsed time. Test 10 assemblies.

3.4.2 Impact - After the storage test of paragraph 3.4.1 above, three of the 10 assemblies shall be subjected to the impact load test of paragraph 3.3 above. Each unit shall be impacted at each of the three temperatures.

3.4.3 Pull Apart - After the storage test of paragraph 3.4.1 above, four of the remaining six assemblies shall be subjected to the pull apart load test of paragraph 3.1. Two units shall be pulled at a temperature of $-25 \pm 5^{o}F$ and the other two units shall be pulled at a temperature of $140 \pm 5^{o}F$. The four units tested shall not pull apart under an applied load of 675 lb. minimum.

APPENDIX B

PLASTIC LABORATORY TEST REPORTS

Honeywell

REPORT NO. (Memo) M1097

DEV. NO. G1000-BB-1000-2714

Contract No. DAK10-77-C-0021

☐ AVIONICS DIVISION ☒ DEFENSE SYSTEMS DIVISION

ENGINEERING TEST REPORT

DATE 18 October 1978 PAGE 1 OF 3

ISSUED BY: DSD-PLASTICS LABORATORY

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C. Schoch MN11-2068
D. Szidon MN11-2480

KEYWORDS:

Urethane
Casting
Physical

ATTACHMENTS:

Figure 1

al

SUBJECT: Improved BLU-63 Molding Process

SUMMARY:

The Plastics Lab has developed a molding process for the improved BLU-63 program using Uniroyal's castable elastomer with Vibrathane B665 and Vibracure No. 3095. The molding process developed was based on that previously used for BLU-61 and is adaptable to that program's automated assembly line.

The improved BLU-63 units were molded using modified BLU-26 diecast dies #DPPM66D12099-T2; five left hand fluted dies and five right hand fluted dies were modified at the equator to conform to the configuration requirements of Drawing #28115052.

Approximately 50 sets of test units were molded in the laboratory and approximately 60 sets of deliverable hardware were molded and assembled and delivered to the designated test facilities. The purpose of this document is to identify the procedure used in molding and assembling the BLU-63.

ACTION:

None - information only.

PROCEDURES:

Section I - Molding Process

Materials required:

1. Vibrathane B665, manufactured by Uniroyal, Inc.
2. Vibracure 3095, manufactured by Uniroyal, Inc.
3. Urethane Red Past #BH, manufactured by Verona Diestuffs, Inc.
4. Hysol 4368 Silicone Mold Release, manufactured by Hysol Inc.

DATA BOOK NO.	PAGE		
708	59, 78, 79, 80		
REQUESTED BY: Dan Szidon	DATE	WRITTEN BY: [signature]	
DEPARTMENT: Development Engineering		APPROVED: [signature]	

HE-44 (DITTO MASTER)
HE-44A
REV 1/77

Section I - Molding Process (continued)

Molding Requirements:

Modified BLU-26 diecast die DPPM65D12099-T2
One small arbor press
One microwave oven for preheating raw materials
One hot air convection laboratory oven for curing product and preheating mold.

Metal Shell Preparation

1. Sandblast part number 9298784 and part number 9298785, Picatinny Arsenal drawings, on the external surfaces to provide a uniform matt finish. Use grit of 80 to 120 mesh.
2. Just prior to molding, wash each shell by immersion in a clean bath of acetone.

Mold Preparation

1. Coat molds with Hysol 4368 silicone mold release.
2. Preheat molds to 250°F until dry.
3. Attach the tungsten metal shell to mold force.

Molding Procedure

1. Preheat Vibrathane B665 to 190°F in a closed container.
2. Preheat Vibracure 3095 to 250°F in a closed container.
3. Weigh 100 parts of B665 into a container. Add 1 part Verona Red Paste No. BH. Then add 21.7 parts of 3095.
4. Mix parts A, B, and Die together thoroughly and rapidly using a power rotary shear mixer.
5. Place the mixture in a vacuum chamber and evacuate at between 2 and 4 torr vacuum for a cycle time of 1 minute and 15 seconds.
6. Pour this mixture into the 250° preheated mold and close mold using an arbor press in approximately 30 seconds.
7. Return molds to oven and cure for 1 hour at 250°F.
8. Remove molds from oven and demold while hot.
9. Postcure each part 40 hours at 250°F.
10. Remove parts from oven and remove flash and excess material by hand trimming using scalpel and scissors.

Applying Inert Fill to Internal Areas of BLU-63

1. Materials required:

   -Epon 815 resin manufactured by Shell Chemical Corporation.
   -Curing Agent U manufactured by Shell Chemical Corporation.
   -Aluminum 101 manufactured by Alcoa Corporation.

2. Equipment required:

   -One each upper and lower casting fixtures. See sketches attached.

Process for Casting Inert Fill

1. Weigh 4 parts of Epon 815 into a container.
2. Weigh 1 part of Curing Agent U into the same container.
3. Weigh 5 parts of Aluminum 101 into the same container.
4. Mix material thoroughly using a rotary power shear mixer.
5. Evacuate the entrapped air from the material for 4 minutes maximum at 2-4 torr vacuum.
6. Cast this material through fill holes of fixtures into the BLU-63 cavities at room temperature.
7. Cure this mixture for 4 hours at room temperature.
8. Demold.
9. Clean up flash by hand trimming.
10. Machine any excess length of sprue which is left over from the filling operation.

Final Assembly

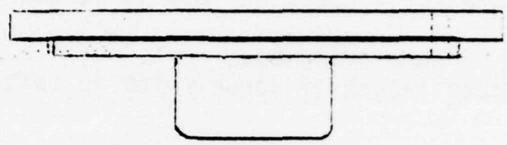
1. Insert one 219E1 fuze spring into top loading assembly No. 28115051-101.
2. Insert one 219E1 fuze into the same side of the assembly with output side of fuze facing upward and away from the assembly.
3. Apply Dow Corning silastic sealant bead so as to create an X across the cavity and onto the equator surface of the part. The bead should be approximately 1/8" in diameter by 1-1/2" long in an X pattern. Immediately after this application apply the base loading assembly No. 28115050-101 in place while locating a stainless steel crimp band No. 28114861-101 between the two mating halves. Place the unit in the BLU-26 crimp die (Honeywell Tool No. X69F4143-T1-1).

   Note: Die should be mounted in a hydraulic press. The press shall then be closed at 800 psi gauge pressure (approximately 22,620 lbs. of force applied to the die).

   Note: Four shims of .062 of an inch thickness shall be located at the closing faces of the crimp die to preclude total closure.

   Remove assembled inert grenade from crimp die and allow to cure for 24 hours at room temperature.

FIGURE 1



Casting Fixture

Honeywell

REPORT NO. T1702

☐ AVIONICS DIVISION ☒ DEFENSE SYSTEMS DIVISION

DEV. NO. G1000-BB-1000-2714
Contract DAAK10-77-C-0021

ENGINEERING TEST REPORT

DATE 17 October 1978

ISSUED BY: DSD-PLASTICS LABORATORY

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KEYWORDS:

Urethane
Casting
Physical

ATTACHMENTS:

Table I, II
Figure 1

al

TITLE: BLU-63, Physical Properties of Molding Material

OBJECTIVE:

Test physical properties of Uniroyal's castable elastomer #665 (M.D.I. base) when cured with #3095 (XA diol). Compare results with vendor supplied data. Determine bond strength in tensile shear adhesion.

MATERIALS TESTED:

1. Vibrathane B665, Lot No. 0083730JG, manufactured by Uniroyal, Inc.
2. Vibracure 3095, Lot No. 0055210, manufactured by Uniroyal, Inc.
3. DK8 Epoxy Powder, manufactured by Hysol Corp.

CONCLUSIONS:

1. Physical properties compare favorably with vendor supplied data and also meet or exceed properties required for BLU-61.

2. Bond strengths to tungsten and steel by simple specimen sandblasting are acceptable and additional preparation is not required.

PROCEDURE AND RESULTS:

Background

Uniroyal's Vibrathane B665/3095 was tested as a low toxicity, moldable, liquid urethane rubber for use on our BLU-61/B production program during 1974, Ref: Test Report T1386. This product proved to be acceptable at that time for use in molding spherical, fluted air delivered bomblets.

During the negotiation of the "Improved" BLU-63 contract (DAAK-10-77-C-0021) with ARRADCOM, this product was agreed upon as acceptable and appropriate to use in our development program.

DATA BOOK NO.	PAGE	
REQUESTED BY: Dan Szidon	DATE	WRITTEN BY: [signature]
DEPARTMENT: Development Engineering		APPROVED: [signature]

E-44 (DITTO MASTER)
E-44A
EV 1/77

Background (continued)

The purpose of this test is to confirm the properties of the specific lots of resin (B665) and hardener (3095) procured for the BLU-63 program. Additionally, tensile shear bond strengths to metal have not been previously determined by either Uniroyal or Honeywell, and were therefore included. A tensile shear strength of 3,000 psi was calculated by Development and Plastics Engineering to be more than sufficient to provide integrity to the BLU-63. Steel to steel bonds with and without a primer were tested for comparison to our normal or routine adhesion test background. Tungsten to tungsten bonds were tested as this is the metal specified for the Improved BLU-63 development program.

Procedure

I. Physical property test specimens were compression molded on a hydraulic molding press using the following conditions:

1. Preheat Vibrathane B665 to 190°F in a closed container (moisture sensitive material).

2. Preheat Vibracure 3095 to 250°F.

3. Weigh and thoroughly mix rapidly 100 p.b.w. to 21.7 p.b.w. 3095 in the polypropylene beakers.

4. Evacuate entrapped air at 2 to 4 torr. vacuum pressure using a 1 minute and 15 second cycle.

5. Rapidly pour this mixture into molds mounted in the press which have silicone mold release applied and are preheated to 215°F.

6. Cure for 10 minutes, minimum, before demolding.

7. For test specimens only, postcure for 48 hours @ 230°F.

8. Cut specimens to appropriate test coupon shapes and age for 7 days minimum at 73°F and 50% R.H.

9. Test per appropriate designated procedure (see Table I).

II. Tensile shear adhesion tests were fabricated of pairs of cold rolled steel coupons measuring 4.5 inches long, 1 inch wide, and 1/8 inch thick. These coupons were prepared as follows:

A. 1 thru 5: Sandblast bonding surface using 80-120 grit.
B. 6 thru 10: Sandblast, followed by dipping in a solution of 7 parts Hysol DK3 epoxy powder diluted by 3 parts acetone. Cure 15 minutes at 400°F.
C. 11 thru 15: Sandblast, followed by electrostatic spray coating DK8 onto coupons using an Ashdee powder spray gun. Cure for 15 minutes at 400°F.

<u>Procedure</u> (continued)

III. Tungsten samples provided by ARRADCOM in the shape of flat precoined BLU-63 subassemblies were cut into tensile shear strips 3 inches long and 3/4 inch wide. The smooth surface intended for the outer walls of the final hemisphere were used for mating adhesion testing. These were prepared as follows:

D. 16-20: Solvent washed in clean acetone.
E. 21-25: Sandblasted using 80-120 grit sand.

Urethane material was prepared identically as in I above. Each prepared set of specimens were coated in their test area by buttering the urethane in place with wooden tongue depressers. All were clamped in a fixture (see Figure 1) at 50 psi and oven cured for 40 hours at 250°F.

Results are reported in Table II.

TABLE I

PHYSICAL PROPERTIES

Test	BLU-61 Drawing 705785	Vendor Published Data	Vendor's Tests	Plastics Lab Tests
Hardness, durometer, Shore D scale	72 ± 3	64 D min.	69D	68D
Tensile strength, psi, ASTM D 412-66T	5500 min.	7800	8150	7540
Tensile modulus (100%) psi, ASTM D 412-66T	3900 min.	4200	4050	4247
Izod impact strength ft./lb. ASTM D 256-56	10 ft./lb. min.	----	25.9	19.74
Compression set % ASTM D 395-61	12% max.	35%	0.5%	0.4%
Tear strength, lbs./in. width ASTM D 470-64T	110 pli. min.	220 pli	160 pli	192 pli
Specific gravity ASTM D 792-66	1.21 max.	1.19	1.19	1.19
Flexural modulus psi ASTM D 790-66	80,000 min.	----	----	103,000
Elongation, % ASTM D 412-66T	190% min.	240%	350%	285%

TABLE II

TENSILE SHEAR ADHESION

Test per ASTM D 1002. Test load rate = 0.2 inch/minute		Average psi	High Value	Low Value
Steel,	A	4130 psi	4550 psi	3730 psi
	B	5200 psi	5570 psi	4880 psi
	C	5760 psi	6010 psi	5550 psi
	Average	5030		
Tungsten	D	4666 psi	4800 psi	4600 psi
	E	5033 psi	5400 psi	4500 psi
	Average	4850		

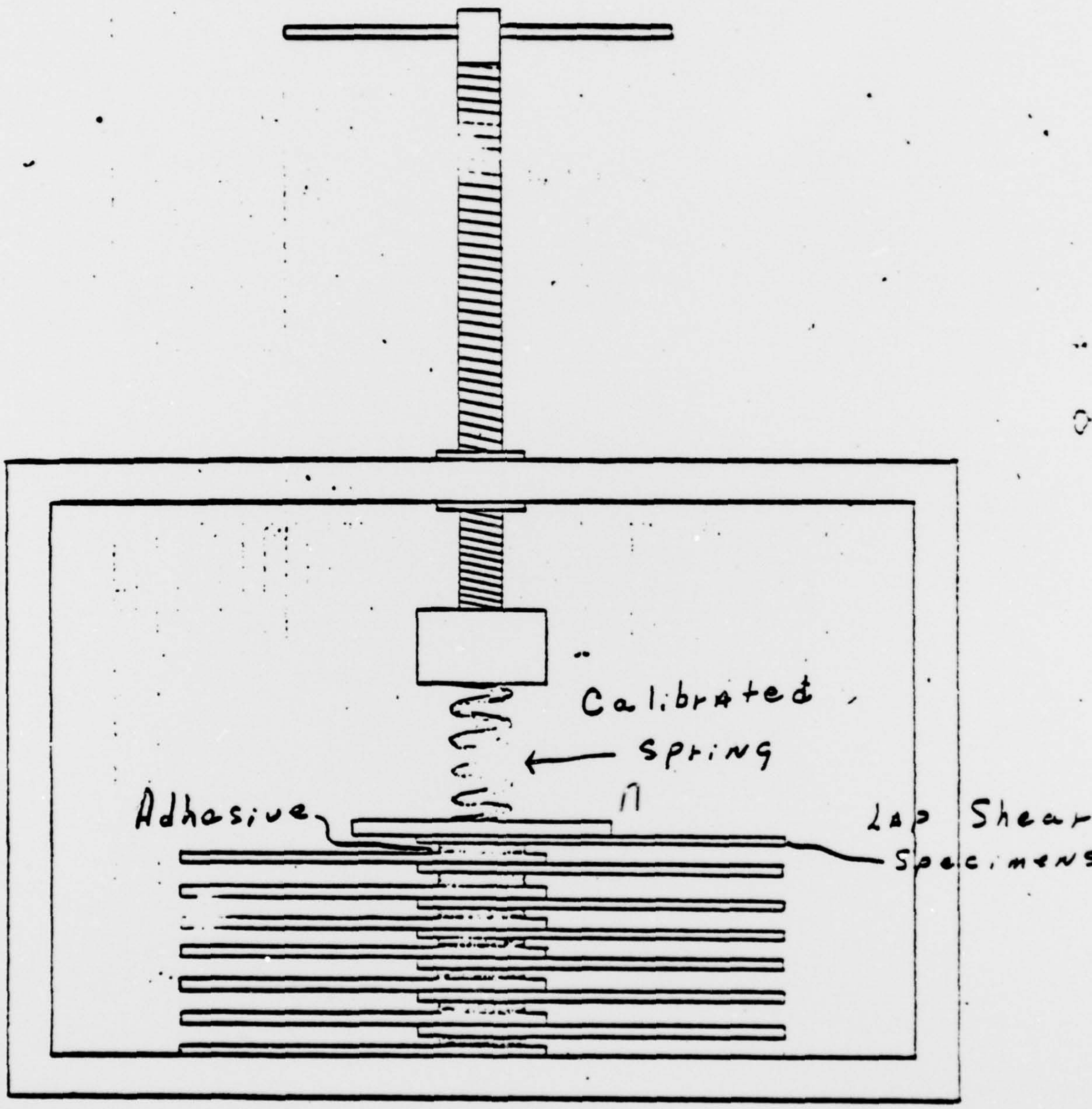

FIGURE 1

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Honeywell

REPORT NO. T1703

☐ AVIONICS DIVISION ☒ DEFENSE SYSTEMS DIVISION

DEV. NO. G1000-BA-1000-2714

Contract No. DAAK10-77-C-0021

ENGINEERING TEST REPORT

DATE 18 October 1978

ISSUED BY: DSD-PLASTICS LABORATORY

TITLE:

BLU-63, Environmental Tests

OBJECTIVES:

1. Simulate typical launch loads as would be imposed by Lance missile firing on the improved BLU-63 grenade, inert loaded and M219E1 fuzed, observe effects.

2. Determine effect of long term storage on improved BLU-63 units by simulating cargo packing and measuring effects in accelerated testing at elevated temperature.

3. Test crimp area strength by pull apart testing of units after storage tests. Test at high and low temperatures.

MATERIALS TESTED:

1. Vibrathane B665 and Vibracure 3095 as molded into: "Grenade, Improved BLU-63, Inert Loaded" per Honeywell Drawing 28115052.

RECOMMENDATIONS:

1. Simulated launch loads to 1,000 lbs. for 2 minutes have no effect on BLU-63 performance as supported by subsequent spinup and arm tests*.

2. Simulated storage at 160°F for 30 days has no effect on BLU-63 performance as supported by subsequent spinup and arm tests*.

3. These units, when subsequently pulled apart, required 1380 lbs. of force at -25°F and 627 lbs. of force at 140°F to achieve separation of grenade halves at the equator.

*Ref: D&E Lab Report OEXM-28830 and 28815.

KEYWORDS:
Urethane
Casting
Mechanical

ATTACHMENTS:

none

al

DATA BOOK NO.	PAGE		
708	59, 78, 79, 80		
REQUESTED BY: Dan Szidon	DATE: 4-1-78	WRITTEN BY: [signature]	
DEPARTMENT: Development Engineering		APPROVED: [signature]	

PROCEDURE AND RESULTS:

Twenty BLU-63 units per drawing 28115052 were molded and assembled by the Plastics Lab using the process described in Lab Report M1097 and urethane rubber as described and tested in Lab Report T1702.

Ten units each were dedicated to testing in I. Simulated Launch Load, and II. Simulated Storage Load as follows:

I. Launch Load Simulation
These munitions as loaded into a Lance missile warhead and launched would see a load of 50 G's as calculated by Development Engineering. A test to simulate this was requested wherein 3 munitions would be nested triangularly within a circular nest and a fourth munition placed on the top center of those on the base. Static loads of 500 lbs. and 1,000 lbs. for 2 minutes each would be applied.

A fixture consisting of 3 inches in length of steel pipe 6 inches in diameter and having an 0.25 inch wall was cut. A 6-inch diameter by 1-inch thick disk of rigid urethane foam at 20 pounds/ft^3 was inserted at the bottom of the pipe to simulate Lance foam cargo trays.

The fixture loaded with 4 munitions was placed in a forced air convection oven and/or low temperature chamber. Two sets of munitions were tested at -25°F and two sets were tested at +140°F. Three hours soak at each temperature was used to achieve temperatures desired.

Fixtures were then placed in the Plastics Lab Tinius-Olsen dynamometer and loaded to 500 lbs. and then examined. The upper munition and 3 lowers were then inverted 180° and subsequently loaded to 1,000 lbs.

The two sets of munitions tested at -25°F showed no visible marks at either load.

The two sets tested at +140°F showed no visible marks at 500 lbs. load but did display visual marks at 1,000 lbs.

The marks visible were created by the sharp (0.005" radius) leading edge of the flutes indenting, one to another. These indentations were 0.002 inch to 0.004 inch deep and tapered to0.0 within 0.15 inches.

Recovery to 50% of the original depth of these marks took place in approximately 1 hour and total recovery in 24 hours.

PROCEDURE AND RESULTS: (continued)

II. Storage Load Simulation

Ten BLU-63 grenades were stacked within an aluminum cylinder 5 inches in diameter x 12 inches deep. A 1 inch thick disc of urethane foam 5 inches in diameter was located at the internal cylinder base (ref. I above). The munitions were oriented so that at least one molded flute of each was pressing against another's flute creating point to point contact pressure (considered worst case cargo loading). These pressure points were marked with black ink for observation and accurate reloading during the test.

The fixture was placed in a forced air convection oven controlled at 160°F ± 3°F for 30 days. It was removed, unloaded, examined and re-loaded within a one hour period, upon completion of 1 day, 3 days, 1 week, 2 weeks, 3 weeks and 30 days.

Upon completion of the first day, each unit was observed to have a "nick" on the leading edge of the flute in contact with another's flute. These depressions could be filled by inserting an 0.005 inch dia. wire to their entirety. No depression was deeper nor more than 0.015 inches long throughout the entire 30 day test. All marks appeared to be permanent as no evidence of recovery was seen within 5 days after the test back at room temperature.

Four of these units were selected for pull apart testing, two at -25°F and two at +140°F. For this test steel bolts 4 inches long and 1/4 inch diameter were threaded into drilled and tapped holes located at the 2 poles spherically opposite the crimp band equator.

The units were soaked for 3 hours minimum time at the test temperature in conditioning boxes (above). They were tested singly by gripping the bolts in jaws mounted in the Tinius-Olsen machine. The machine speed was set at 2.0 inches per minute and a chart recorder was engaged to provide permanent record of force to break, or separate the grenade halves.

RESULTS:

			Separation Force
-25°F	Unit 1	=	1385 lbs.
	Unit 2	=	1375 lbs.
	Average	=	1380 lbs.
+140°F	Unit 3	=	655 lbs.
	Unit 4	=	600 lbs.
	Average	=	627.5 lbs.

Note: Two units previously tested of this crimp band/lip configuration, during development, were each loaded at the above rate to 1,000 lbs. without failure. One unit was then pulled to failure at 1237 lbs. These were tested at room temperature.